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The emergence of an adaptive response network: The April 20, 2013 Lushan, China Earthquake

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ABSTRACT

We employ a theoretical framework of complex adaptive networks to explore how China's comprehensive emergency management system, initiated after the SARS Epidemic, adapts to extreme disasters in the centralized political context of China. Based on the multi-organizational responses to the Ya'an Earthquake, April 20, 2013, China, we identify the emergence of the response network, and analyze the interactions among organizations and information infrastructure supporting such interactions. Our findings suggest that a network structure, with expansion in both size and variation, emerged after the Lushan Earthquake. Emergence of this response network is determined by not only interorganizational interactions among public organizations and public service entities, but also cross sector interactions between public organizations and private and nonprofit organizations. However, interactions are insufficient not only between public organizations and private and nonprofit organizations, but also among public organizations at the municipal and county levels, particularly in the initial stage of the response. The lack of cross sector interactions between public organizations and private and nonprofit organizations limits command and coordination of the whole network in achieving a collective performance. Accordingly, in information processes, communication infrastructure was not sufficiently strong to support these two types of interactions. Policy recommendations are offered to improve preparedness of the response plans, emergence of response networks, as well as information infrastructure to support interactions among organizations in disaster operations.

1. Introduction

How emergency response systems adapt to extreme disasters is a central issue of disaster and emergency management research. The process of adaptation depends upon, and varies with, political contexts in different countries. In the centralized political context of China, how do emergency response systems adapt to extreme disasters? This question has not yet been fully explored in academic research.

In the aftermath of the 2003 SARS Epidemic, China developed a comprehensive emergency management system to respond to all types of disasters, ranging from natural hazards, industrial accidents, epidemics, to social riots (Zhang, 2012). We examine the performance of the system based on the response network documented after the April 20, 2013 Ya'an Earthquake in Lushan County, Sichuan Province, China.

We address four questions in the centralized political context of China. First, how do networks emerge in responding adaptively to extreme disasters? Second, which organizations participated in the emergence of response network in Lushan County? Third, what functions did the response network perform in the context of Lushan County? Fourth, how can the performance of future response networks be improved in China?

2. Adaptation of emergency responses in extreme disasters

There has been a long history in studying emergency response operations following disaster situations since the 1960s (Dynes, 1979; Drabek, 1994; Tierney, 1994). In recent decades, research studies have mainly focused on extreme disasters, such as the "9/11" Terrorist Attacks, 2001, Hurricane Katrina, 2005, Tohuku Earthquake, Tsunami, and Nuclear Breach, 2011, and Superstorm Sandy, 2012. These research studies can be divided into three sub-topics.

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First, how do networks emerge in dealing with extreme disasters adaptively? Comfort (2002) demonstrated the limits of governmental performance in the 9/11" Terrorist Attacks, and redefined the governmental function of providing security as a complex adaptive system, which required a network of participants that increased in both size and variation. Tierney and Trainor (2003) identified a multi-organizational network that emerged in New York City after the 9/11 attacks, and illustrated how the emergent networks enhanced resilience by increasing the availability of information and resources. Similarly, Kendra et al. (2003) observed the evacuation of lower Manhattan by water transportation, and demonstrated the success of the decentralized response networks.

Second, how do interactions among organizations determine adaptation of the emergent networks? Waugh and Streib (2006) examined how the lack of collaboration in the evolution of emergency management resulted in the failure of response to Hurricane Katrina. Wachtendorf (2006) highlighted the lack of improvisation at the organizational and multi-organizational levels and the inability to develop a shared understanding of roles, responsibilities, and capacities. Comfort (2007) illustrated the collapse of the standard model of emergency management without a clear focus on the role of cognition, and redefined cognition, communication, coordination and control in ways that fit the reality of practice in extreme events. She suggested that design, self-organization, and feedback were central to effective performance of diverse organizations. Kapucu et al. (2010) found unsuccessful use of intergovernmental and interorganizational resources in coordination, and advocated a network-centered approach focusing on collaborative efforts at local, state, and federal levels.

Third, how does information facilitate interactions among organizations in emergent networks? Comfort and Kapucu (2006) examined the performance of inter-organizational coordination in the "9/11" Terrorist Attacks, and highlighted the importance of investment in developing an information structure to facilitate information search, exchange and feedback in an auto-adaptive system. Comfort et al. (2013) contrasted preimpact plans with observed networks of action, and examined the policy problems and information gaps involving interaction and communication among organizations engaged in the response to the 2011 Tohoku Earthquake and Tsunami. In the recent research, Comfort et al. (2014) identified a multi-organizational response network, and documented information gaps among different types of organizations, particularly the lack of communication between governmental agencies and business organizations in 2012 Superstorm Sandy.

In common, all these studies identified three sequential factors critical for adaptation of responses to extreme disasters. First, network structure, particularly the decentralized structure with massive and diverse participating organizations ranging from governmental agencies, private sector, and nonprofit organizations, were more adaptive in actual response operations than specified in predefined plans. Second, in this network, the adaptive capacity was further determined by interactions among all participating organizations. Repeated interactions facilitated these organizations in adapting to each other to achieve a collective performance in a timely manner. Third, interactions among these organizations were further influenced by information capacity, that enabled these organizations to search more broadly to determine what should be done and to adjust their actions according to this bigger picture through timely information exchange. These three factors were not operating in parallel, but moved forward sequentially. They constituted the basic chain of interdependent actions to show how an actual network operated in the response to an extreme disaster.

The studies cited above were conducted in largely decentralized political contexts, particularly the federal administrative context of the United States. These studies are unique in revealing the relationships among governmental agencies, private sector, and nonprofit organizations, as well as the relationships among governmental agencies at various levels (Landy, 2008). The existing relationships among organizations prior to disasters potentially determined the emergence of relationships among organizations in the response (Waugh and Streib, 2006; Comfort, 2007). As a result, notwithstanding the information process, the emergence of networks in disaster responses might vary with political contexts because of the differences in pre-existing relationships among organizations.

In the centralized political context of China, the existing relationships among organizations prior to disaster are significantly different from that in the federal administrative structure of the United States (Tierney, 1994). However, there are few studies based on the centralized political context of China to date (Xu et al., 2014; Zhong and Lu, 2015; Guo and Kapucu, 2015). To fill this gap, we seek to document how organizations involving in the comprehensive emergency management system adapt to extreme disasters in the centralized political context of China.

3. Evolution of emergency response in China

In the aftermath of the 2003 SARS Epidemic, China initiated the development of a comprehensive emergency management system to deal with all types of disasters, ranging from natural hazards, industrial accidents, epidemics, to social riots (Zhang, 2012). In the stage of response, two institutional designs have been implemented. Vertically, responsibilities of governments at various levels have been clarified according to the severity of disasters. Horizontally, responsibilities of governmental agencies at each level have been specified according to their authorities.

Besides governments, state-owned companies and public institutions also function as public service entities, and keep a close relationship with governments. As a result, they are included in the comprehensive emergency management system. However, nonprofit and private organizations have not yet been formally included, although the 2008 Wenchuan Earthquake demonstrated their emerging roles in disaster response operations (China State Council, 2009).

In order to enhance preparedness, millions of emergency response plans have been developed by governments at various levels and by governmental agencies at each level, as well as by state-owned companies and public institutions. Table 1 shows how authority for managing response operations is assigned by severity and jurisdiction based on the National Earthquake Emergency Response Plan (NEERP).

4. Theoretical framework of complex adaptive response operations

Disaster response systems have been recognized theoretically as phenomena of emergence in complex operations (Perrow, 1984; Drabek and McEntire, 1985), and the emergence of networks of response to extreme disasters have been further redefined as complex adaptive systems (Comfort, 2002, 2007; Helsloot et al., 2012). In this sense, as phenomena of emergence in complex systems, the actual networks are consequences of complex adaptive response to extreme disasters. Its operations depend on two interrelated factors: (1) interactions among participating organizations, which are largely affected by pre-existing relationships among organizations and (2) information processes supporting such interactions, which are potentially determined by information infrastructure.

Interactions among organizations are identified in two dimensions: (1) interorganizational interaction within public organizations, mainly referring to intergovernmental interactions among governments at various levels and interagency interactions among governmental agencies within each level; (2) cross sector interac-

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